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An Engineering Program Built Around Work

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ABSTRACT: The College of the Ozarks began a four-year multi-disciplinary engineering program in the fall of 2016. This is the first four-year engineering program at a federally recognized work college. The program content and overall structure are influenced by the work program, College goals, and a desire to minimize impact on existing College programs. At the College of the Ozarks, all full-time students work to help cover the cost of education. The campus is built with student labor and college functions are largely conducted by students. This College work component provides challenges in areas such as student schedules and workload. However, the graded work experiences also provide opportunities to increase work maturity, build ties between the program and the campus community, and enhance Christian formation efforts. In addition to the unique work component, the College's regionally-focused mission to provide a Christian education based in the liberal arts for those who could not otherwise afford it results in a unique student population and customer base. Comparisons to other engineering programs highlight both the challenges and the value of the two-part approach, which accommodates the general education component while providing both breadth and opportunities for engineering discipline-specific concentrations.

Keywords: work college, curriculum, multi-disciplinary engineering, program development

A Mission-Driven Institution

College of the Ozarks is a work college. Like the other eight federally recognized work colleges, it engages students in an integrated work-service-learning experience. Although this economic model is only operating at small institutions,[1] the institutions are diverse in focus and approach to education.[2] College of the Ozarks' unique focus traces back to its founding as a high school in 1906 by a Presbyterian minister to address the extreme needs present in the Ozark region.[3] The mission of the now four-year liberal arts and sciences college remains as it was at its founding, focused on providing an education to financially needy youth:

> The mission of College of the Ozarks is to provide the advantages of a Christian education for youth of both sexes, especially those found worthy, but who are without sufficient means to procure such training.

Working in exchange for schooling remains the centerpiece of the College experience. Some of the 100 workstations have existed since the beginning, such as management and care of beef and dairy cattle, and meal preparation. Others, such as working the IT help-desk and staffing the number two rated small hotel in the U.S.,[4] are more recent. Some workstations reduce college

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costs, such as custodial and construction. Others, such as the restaurant, hotel, and farmer's market generate income. Regardless of their workstation, all students spend a minimum of 15 hours a week during the semester plus, one 40-hour week, laboring to contribute to their tuition-free education each semester. Students with the greatest financial need are able to work 40-hour weeks on campus through the summer in return for room and board for a year. A third of the students also work off campus to provide funds for books, clothes, and spending money.

Work at College of the Ozarks is intended to be more than simply a means to a financial end. The underlying college ethos is that work is part of our royal charge to watch over and exercise dominion over creation[5] that runs throughout the Biblical narrative from the first to the second Eden.[6] As such, work is a worthy and sanctifying experience, essential to enjoying our relationship with the Creator.[7] It is also something that benefits from being performed in a cooperative community that provides encouragement and opportunities to practice Christ-like behaviors that will serve students well after graduation. It is not by accident that the first all-college chapel service each semester takes place during a day reserved for work station orientation and students attend with their work station coworkers and supervisors.

The College vocational, Christian, patriotic, cultural, and academic goals work together to produce graduates who positively impact the region. It would be unusual to find an Ozark school district without a College of the Ozarks educated teacher, just as many fire departments in the region have veterans of the College fire station, and numerous water treatment plant operators learned their trade at the College plant. Similarly, many Ozark pulpits and Christian non-profits are staffed by College graduates. While it is the business of a Christian institution to help students find a suitable vocation,[8] this paper instead focuses on the work done by the students in the College work program which is not necessarily aligned with a future vocation. We will, however, discuss how this work program creates Christ-like character traits that are important across all vocations, particularly engineering.

College of the Ozarks is now unique among work colleges by virtue of having a four-year engineering program. Being a work college does not a priori mean the curriculum is different than that of other institutions. However, addressing the needs of the Ozarks region and supporting the College mission have uniquely shaped the engineering curriculum content and structure.

A Focused, Regional Endeavor

According to Chronicle of Higher Education, the College is the 7th most selective private four-year college in the nation, with a 12% acceptance rate.[9] Not surprisingly, the primary admission criteria are financial need and Ozarks region residency. Not only do many students come from financially stressed home situations, but also from financially challenged school districts. As a result, worthy students may arrive poorly prepared in math, science, and communication skills. The engineering curriculum is designed to accommodate these students as much as possible, for example allowing them to start in trigonometry, or in remedial English composition, and remain

with their cohort. The entire College faculty is incentivized to help students succeed as rapidly as possible, since a student staying longer not only fails to bring in additional revenue but also denies a slot to another prospective student. Similarly, the program size is capped, since additional engineering majors would come at the expense of reductions in other majors. "Growth" must be in terms of improved student retention.

As with most regionally focused engineering programs, the faculty and staff visited employers in the region to understand their needs and the characteristics they desire in our graduates. Industry is dominated by small to medium size family-owned businesses, primarily in the areas of tourism, agriculture, and light manufacturing. The work of many smaller firms is often diverse and must adapt to follow the economy. They either employ a few engineers or contract out their engineering work. Firms know of the College either by reputation or family ties or, often, because they have hired a graduate. It has become a common request to provide engineers who get along with those different from themselves and are not above doing the lowly jobs[10] – characteristics "like the last College of the Ozarks graduate we hired".[11] Larger firms add several additional requests: engineers with roots in the area who will stay more than two years, who are willing to learn, and who have effective communication and interpersonal skills, both for effectiveness within the firm as well as with customers. Based on conversations with employers, teaching general workplace skills seems to be neglected in bachelor-level higher education. Perhaps the assumption is that these skills are learned at home or at a first job. This does not appear to be a broadly valid assumption based on our discussions with regional employers and College administration. As a result, the College strives to ensure workplace skills such as effective communication and getting along with coworkers are addressed prior to graduation.

So, a challenge for the program is to produce versatile entrepreneurial engineers who retain the desired characteristics of humility, a good work ethic, responsibility, getting along well with others, and effective communication. It is the opinion of the department faculty and staff that one key to producing these traits in engineering graduates is the work program in its overtly Christian context.

Students receive semester grades for their work from their work station supervisor, and their work GPA is reported on their transcript. The result is a work program that students take seriously and thus is able to shape them in interesting and helpful ways. In their work stations, students work and interact with a wide variety of students, faculty, staff, and the public. They do not get to choose the coworkers with whom they must cooperate to successfully accomplish their assigned tasks, with the result that graduates tend to possess a workplace maturity desired by employers. Their supervisors model Christian leadership and, in many workstations, the students get to practice their supervisory skills under the mentorship of the work station supervisor. Such mentorship is critical to developing Christ-like character traits.[12] Students learn life skills such as dealing with conflict in the workplace, following instructions, punctuality, accepting responsibility, and reaping the benefits of quality work. A great example of the latter is the cleanliness of our toilets. Students generally do not want to remain on custodial crews, so they

strive to get a good work grade and supervisor recommendation, thereby maximizing their chances to secure a workstation more to their liking in the future. The result – our restrooms may be among the cleanest of any engineering program in the country. Moreover, they tend to stay clean, because students learn to respect the fact that their fellow students are the ones cleaning up after them.

Conflict resolution skills, cheerfulness, reliability, humility, respect, teamwork and appreciation are among the "others first" attributes valued by employers and are an integral part of the work program and Christian formation efforts at the campus. A persistent challenge for functionally organized Christian institutions is to help the students live coherent lives as described by Garber[13] and to avoid unnecessary and detrimental compartmentalization of work, spiritual, and academic development.[14] For College of the Ozarks, the ubiquitous work program seems to be a key to bridging the divides. For example, the common work station grading rubrics specifically incorporate desired character traits that are part of the College's Christ-like Character Initiative: wisdom, hope, humility, citizenship, and courage. The rubrics are included in the appendix. Note that these may be further adapted to the specific tasks required by each work station. The common work program provides opportunities in the engineering program to discuss work as a blessing and how students' developing workplace skills and attitudes will benefit an engineering profession, something that is critical as many of our students have limited exposure to professions beyond those of the teachers they encountered in school and pastors in church.

Challenges and Solutions

Implementing an engineering program at a Christian, liberal arts work college is not without challenges. Foremost among them is the increased student workload due to simultaneously fulfilling College and engineering program objectives. Second is fitting into the existing College structure while minimizing negative impacts to College finances and faculty and staff workload. College of the Ozarks' general education component consists of 43 credits, and our math and science sequence is 36 credits, a bit larger than the ABET-required 32 found in the vast majority of engineering programs, as highlighted in the Table 1 comparison. As a small school with limited teaching resources, the luxury of engineering-specific math and science courses is beyond our means, so we must use or augment what resources are available; for instance, to accommodate the engineering program schedule, the math department now offers previously existing courses more frequently. One benefit of this approach is the new program uses existing courses that are proven and tailored to the typical Ozark-region high school graduate. The math and composition sequences, in particular, are designed to assist students arriving with deficiencies. As an example, the pass rate for the courses in the calculus sequence is over 80%.

Another example involves the fact that we could only fit the extant Chemistry I course into the curriculum. We feel strongly that our graduates should know how chemical engineers formulate and tackle problems. The result is that our introduction to chemical engineering course must introduce a few topics that would normally be covered in a second chemistry course. Thus, we have a somewhat unique course, which makes finding suitable texts a challenging proposition.

This is on top of limitations due to cost. While some of our students have textbook scholarships, paying for expensive texts contributes to the trend of working off campus during the semester, an activity that is detrimental to academic success for many students.

Accommodating the liberal arts, Christian, and patriotic courses that are critical to character formation stands in contrast to many engineering programs with general education content as low as 18 credits. To put it in perspective, in Figure 1we plotted the ABET general education category for the programs in Table 1 against their ABET engineering science and design credits. Our core program is the open marker labeled "1". Points below and to the right are those programs pursuing a more technically focused curriculum balance, likely in response to their particular competitive landscape. As those programs strive to ensure their graduates secure good positions, maximizing engineering credits is viewed as critical. However, given our focus on retaining those desirable attributes of prior College graduates, we retained the entire general education core that is critical to providing those attributes.

Even with such challenges, we also have a distinct advantage in our regional focus on an area of the country that tends to be ignored by many graduates of established schools. This provides some flexibility in our approach to meeting industry calls for broadly educated engineers. We acknowledge that some of our students and their potential employers may want more traditional specialization than our core program offers. To that end, we are creating optional concentrations, which add four courses, placing the student's engineering course exposure on par with more traditional programs. That credit count with the concentration is shown by marker "2" in Figure 1. Creating these concentrations raises some interesting stewardship questions for us. First, it means a student would likely attend for an extra semester. Recall that doing so prevents a new freshman from enrolling. Needless to say we expect to be somewhat selective with concentration candidates. Also, as a small school, we are unable to offer the number of courses required to implement this approach across multiple engineering disciplines; instead, we are starting with the College's traditional strength (agriculture) and foundational disciplines (civil, electrical, mechanical, and industrial/systems) and are pursuing partnerships with other schools who possess online and remote delivery courses.

Nearly all programs we examined encourage internships and many actively aid their students' efforts to locate internships. Yet far fewer give students program credit for their internship efforts and, as a result, faculty participation is often limited. Of the eight benchmark programs in Table 1, only four give any credit for an internship, with only one of those offering an opportunity for use of an internship as a technical elective and one as a broadening elective. Recall that, as a work college, we mentor and grade work and include it as an integral part of the formation process. Thus, to not consider an internship as an extension of other work maturity development efforts would be inconsistent with our approach. Adding the internship credit, which is required for a concentration, results in the credit profile shown by marker "3" in Figure 1.

	Total Credit Count	Math and Basic Science	Engr Science and Design	General Education
ABET reference	*128*	*32*	*48*	-
CofO engineering	136	36	57	43
Benchmark 1	134	32	59	44
Benchmark 2	134	32	67	35
Benchmark 3	138	32	69	37
Benchmark 4	135	33	70	32
Benchmark 5	128	32	65	31
Benchmark 6	134	32	75	27
Benchmark 7	128	32	74	22
Benchmark 8	126	32	76	18

Table 1. Credit comparison against eight benchmark programs

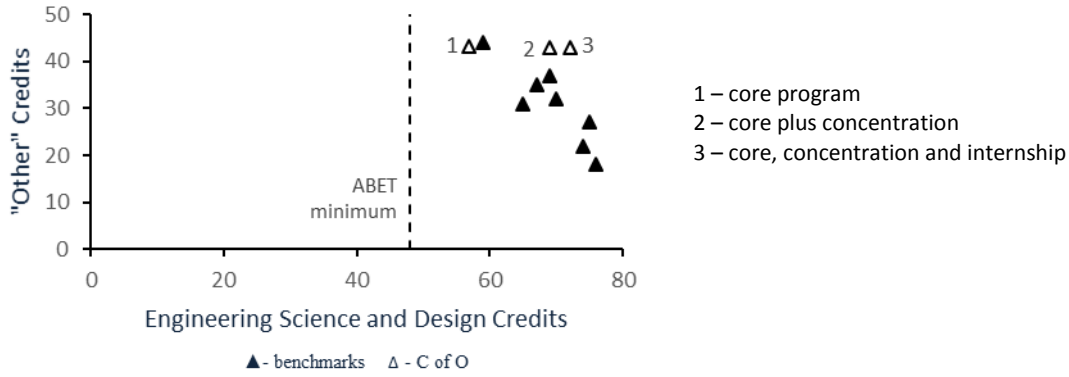

Figure 1. Credit comparisons with program alternatives

Time is precious and particularly so for our students. To complete our program and work at least 15 hours a week (more if a student is banking hours in anticipation of future interruptions such as student teaching or athletics) students are in violation of the 60-hour rule.[15] Add to this off-campus employment and extracurricular activities, and students' academic performance suffers, with demoralization not far behind. We are quite challenged to effectively encourage diligence and enjoyment of God-ordained work, including course work, in our engineering students.[16] We discourage off-campus employment and seek ways to reduce the cost of textbooks and provide financial help to those students who do not have book scholarships.

The next few years promise to be exciting, with a variety of challenges awaiting us and our first graduating class. For example, past College graduates have commented on the shock of leaving the protective bubble of the College and local community. To help students encounter the broader world, the College travel program provides free trips to students, again aligned with the College goals. As this paper was being written, for example, one of the engineering majors was in Vietnam as part of a series of patriotic trips escorting veterans back to the battlegrounds where they fought. Here, the students received a critical cultural lesson in addition to a patriotic one.

We expect and encourage our students to participate in mission trips and internships that take them outside of their historic comfort zones. These valuable experiences will add to the workload challenges our students face.

Other engineering program plans include giving back to the College through tutoring and similar activities in our student-built facilities. The goal is to counter the "math and science are too difficult" mentality that can hinder non-STEM majors' engagement with their world, and reinforce the value of liberal arts to engineers. The objective is to engage in some meaningful way with each academic department, with the aim of furthering the ability of our graduates to engage their world. For example, with the psychology department we are exploring inviting a psychology professor into an engineering course to discuss topics dealing with value-laden technology. We are also considering an acoustics elective which would be designed for music, mass communication, and engineering majors.

Finally, and very much a work in progress, is a desire to supplement ABET knowledge and skill assessment with an assessment of developing attitudes. As with our other efforts, we will not be doing this alone but as part of the larger College community and the Christ-like Character Initiative, and we are excited to integrate this initiative into the engineering program.

Summary

As with other engineering programs that align with their constituencies, the College of the Ozarks curriculum is aligned to the unique needs of the Ozarks region and to the existing College structure and philosophy. It is the work program that makes the College of the Ozarks' engineering program unique among other programs. Work, the general education component, and communal worship are common bonds for the College community and as such play a critical role in developing an inclusive and common community identity. Learning effective stewardship of time and resources is a natural outgrowth of the communal work approach, which provides a fertile ground for lessons in citizenship, in addition to academic and Christ-like character development, thereby addressing all five of the College goals for graduates and we believe, creating desirable attributes in our engineering graduates.

Notes

[1] Work college sizes range from 110 to 1625 students.
[2] *Meet the Work Colleges*. The Work College Consortium, http://www.workcolleges.org/node/30, accessed 25 March 2017.
[3] Davis, Jerry C. *Miracle in the Ozarks*. Point Lookout MO: College of the Ozarks, 2007.
[4] *Best Small Hotels in the United States - TripAdvisor Travelers' Choice Awards*. Trip Advisor, www.tripadvisor.com/TravelersChoice-Hotels-cSmall-g191, accessed 25 March 2017.
[5] Genesis 1:26-28.
[6] Todd III, James M. "Edenic Endeavors: Sacred Service in the Garden of Eden." *Faithful Lives* 1 (2016): 11-20. Many authors have written about the Biblical perspective of work in general, which is what is referred to here. While not the focus of the College work program, the authors note the overlap with the growing body of literature examining the Biblical call to engineering specifically. See for example Jordan, William. "The 21st Century Calling of the Christian Engineer." *Proceedings of the 2015 Christian Engineering Conference*. Seattle, 2015. 57-71.
[7] Hamilton Jr., James M. *Work and Our Labor in the Lord*. Wheaton: Crossway, 2017. 50-53.
[8] Foster, Michael and Justin Vander Werff. "Finding Your Path." *Proceedings of the 2015 Christian Engineering Conference*. Seattle Washington, 2015. 72-79.
[9] Hammond, Ruth. "Yield Rates at the Most-Selective 4-Year Colleges, Fall 2014." *The Chronicle of Higher Education* 5 January 2017. http://www.chronicle.com/article/Yield-Rates-at-the/238900.
[10] Employers in our region agree with Vander Werff and Foster's view that being a humble servant is a critical engineering trait. See Vander Werff, Justin and Michael Foster. "Servant Leadership in Engineering Education." *2011 CEEC Proceedings*. Langley BC, 2011. 114-122.
[11] Employers care about the behaviors of their workforce which Anson notes for engineers may be perceived as simply "practicing engineering 'Christianly.'" An effective way to ensure these Christ-like practices are produced is to view a vocation, engineering or other, as a calling. Anson, Scott. "Why Engineer - A Biblical Perspective on the Engineering Profession." *Proceedings of the 2015 Christian Engineering Conference*. Seattle, 2015. 80-90.
[12] Garber, Steven. *The Fabric of Faithfulness, expanded edition*. Downers Grove: IVP Books, 2007. Ch 6.
[13] Ibid, Ch 5.
[14] Beuttler, Fred W. "Moral Philosophy in a Social Scientific Age: A Proposal to Reintegrate the Undergraduate Curriculum." *Christian Higher Education* (2012): 11(2), 81–93.
[15] Landis, Raymond B. *Studying Engineering: A Road Map to a Rewarding Career, 4th Edition*. Anaheim: Discovery Press, 2013.
[16] Ecclesiastes 2:24.

Appendix: Work Grading Rubrics

Work Traits	Grade Scale	
RELIABILITY Absenteeism and punctuality; degree to which assigned schedules and tasks are met Trustworthiness, diligence in completing assigned tasks, does not give up when frustrated, can be depended upon to get tasks done even in the absence of the supervisor.	0	25
	Unreliable	Extremely reliable
TEAMWORK/COLLABORATION Willingness and ability to work with others: collaboration and support Displays humility when working with others, serves and supports others, has a joyful heart when working with others, is fair and creates workplace harmony, demonstrates justice and shows personal responsibility and teamwork when working with others.	0	10
	Does not support team or group tasks	Continuously outstanding team member
INITIATIVE/MOTIVATION Self-starting and ability to adjust and adapt as needed to change Demonstrates courage and pushes beyond self-limits, perseveres through change and disappointments, and maintains a good attitude.	0	20
	Takes minimal or no initiative and is inflexible	Completes all tasks with minimal or no direction and is flexible
RESPONSIBILITY/ACCOUNTABILITY Work ethic, takes responsibility for actions, integrity, and proper care of equipment when applicable Demonstrates hope with a good work ethic, displays self-control, courage to admit mistakes, ethical in all matters, even when others are not.	0	20
	Poor work ethic, irresponsible	Outstanding work ethic, shows great responsibility and integrity
QUALITY OF WORK Degree to which pride is taken in successful performance of all tasks and work is of high quality Seeks to hold to high standards, demonstrates wisdom by consistently pursuing improvement in performance and knowledge of work to be done, listens and seeks advice of others, and maintains a joyful attitude, no matter the circumstances.	0	15
	Little or no regard for quality of work	Performs highest quality work at all times
COMMUNICATION SKILLS Ability to effectively communicate with supervisor, peers and/or customers Treats others with honor and respect, courage to raise difficult issues/questions without a demeaning attitude, compassionate, patient, and calm.	0	10
	Makes little effort to communicate effectively	Maintains clear and concise communications